The Volcanos of Lanzarote and Fuerteventura

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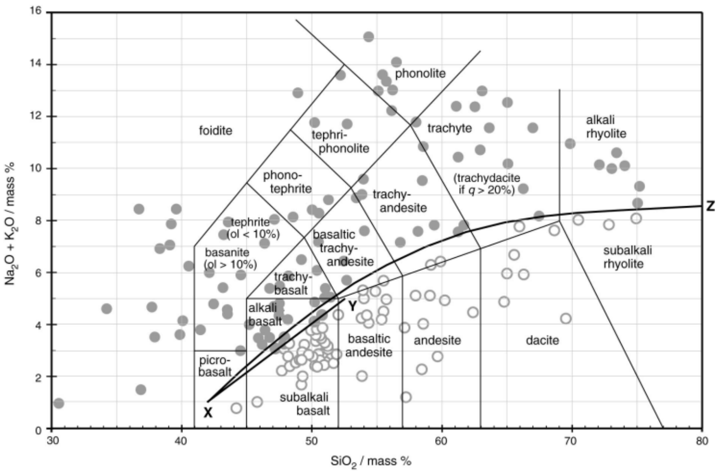
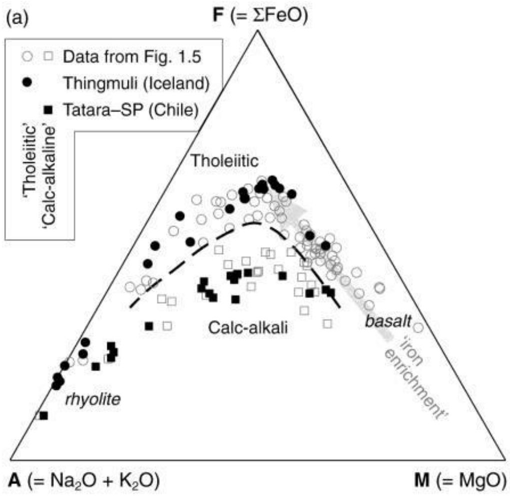
Basalts are fine-grain basic igneous rocks. They are found in many tectonic settings and are the main building blocks of these volcanoes. Two distinct types are commonly found in oceanic volcanoes:

- Mid Ocean Ridge Basalts (MORB) result of partial melting upper mantle which has already been recycled many times.
- Ocean Island Basalts (OIB) result of at least some partial melting from a deeper mantle source. They are less depleted in incompatible elements.

The diagrams below are used to define the type of magma involved in an eruption. The Total Alkali Silica (TAS) diagram (left) shows the compositions of volcanic rocks. Alkali rocks sit above the line XZ with the Subalkali rocks below. The type of magma from a volcano can change over time, e.g. evolving from basalt to rhyolite. The second diagram (right) shows 2 main trends either side of the dotted line, called either 'tholeitic' or 'calc-alkali' depending on how iron rich they become. The diagrams are both from 'Igneous Rocks and Processes' by Robin Gill.





There are 4 main settings which relate to Oceanic volcanos.

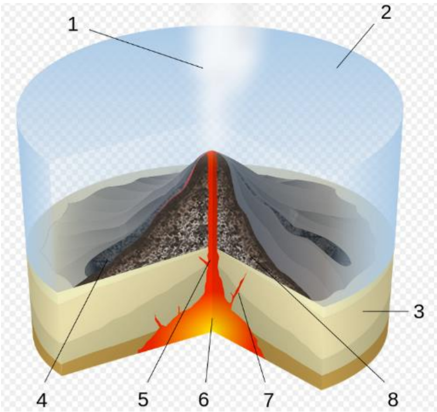
- Subduction related volcanos. These usually form stratovolcanos and arise in 2 ways:
    - Ocean/continent boundaries typically around the ring of fire. The continental crust that has been incorporated will contaminate the magma from these volcanoes.
    - Ocean/ocean boundaries such as in the South Sandwich Islands. These have very primitive magmas, which have not been contaminated, by crust.
- Mid ocean ridge volcanos. These are fairly uncommon, as they do not normally rise above the ocean surface. Iceland and Azores are the best-known example of such volcano types. They are formed of MORB tholeiitic magma and are thought to arise when a plume happens to be sitting under a mid ocean ridge.
- Transform or conservative plate margin volcanoes. These are rare and arise when there is magma leakage from a transform fault. They usually only form a sea mount.
- Oceanic Intra-plate volcanoes. A common setting, often forming linear lines of volcanoes and thought to be related to the presence of a mantle plume. Composed of OIB, they sit in

the middle of an oceanic plate, famously Hawaii and Canaries. Changes in direction of the line indicate a change in direction of plate movement – see Hawaii for an example. These magmas can be either tholeiitic or calc-alkali.

To build an oceanic volcano:

- Need a magma source.
- It needs to be able to penetrate the oceanic crust; this doesn't always happen and the magma may solidify below the crust.
- Need more magma emplaced than eroded by the ocean to build up firstly an underwater seamount.
- Having reached sea level, it can then start to build a volcanic island.

This is a schematic layout of a seamount.



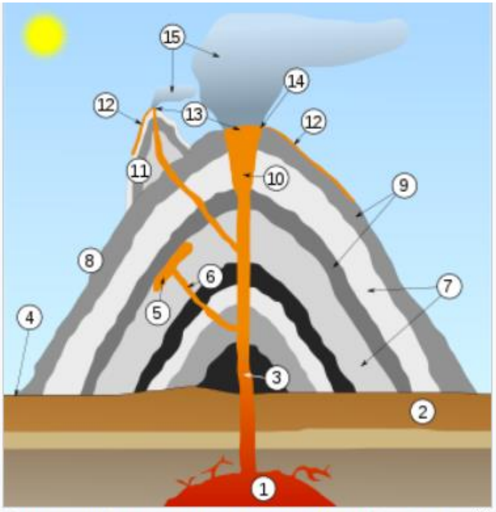
Key 1=vapour, 2=water, 3=Sediments, 4=lava flow, 5=conduit, 6=magma chamber, 7=dyke, 8= Pillow lava

Kavachi -breaking the surface

This volcano has erupted 33 times since 1940 but has never managed to build a substantial new island.

This is a typical volcanic island with a central vent building a roughly circular island (Mount Cleveland © NASA)

The basic structure of a stratovolcano is shown in these 2 schematics – the first a very basic view, the second a more realistic one.



Cross-section through a stratovolcano (vertical scale is exaggerated):

1. Large magm
2. Bedrock
3. Conduit (pip
4. Base
5. Sill
6. Dike
7. Layers of as
8. Flank
9. Layers of la
10. Throat
11. Parasitic co
12. Lava flow
13. Vent
14. Crater
15. Ash cloud

© Kids Search

The structure below shows a massive magma chamber (batholith) feeding one or more lava dykes as part of a complex underground sub volcanic plumbing system (© 2017 Dougal Jerram, Alwyn Scarth and Jean-Claude Tanguy). It's possible that much of the lava will never get to the surface but remain in underground reservoirs (laccoliths).

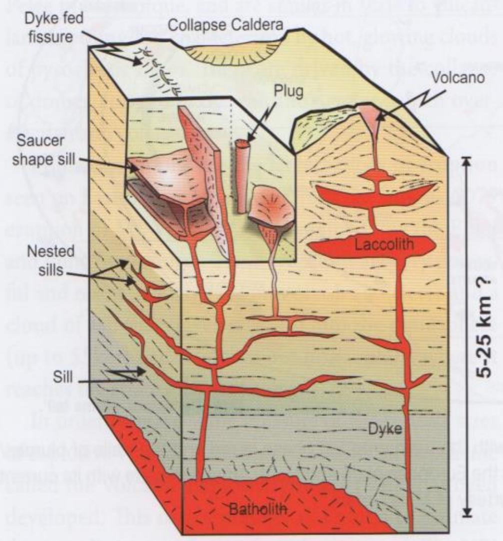
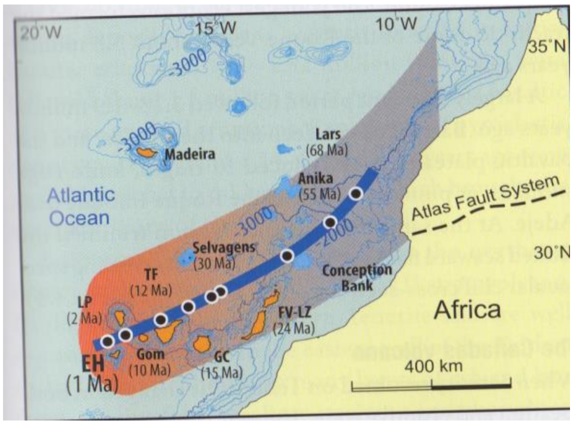
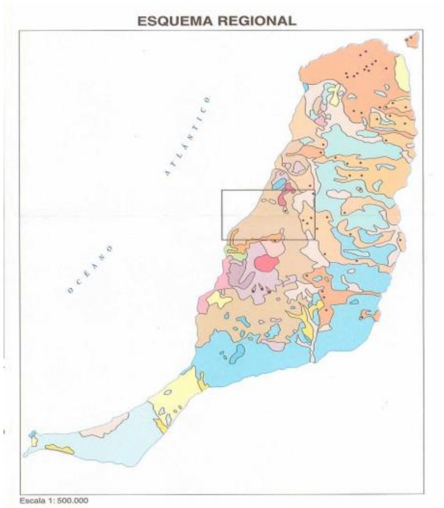


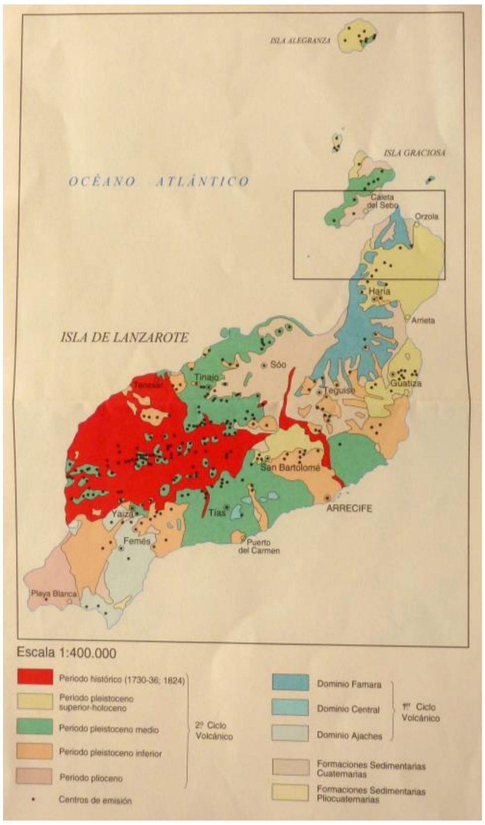
Figure 1.9 Schematic to show the types and styles of plumbing system beneath volcanoes.



The Canary Islands sit off the southern border of Morocco and there is a clear trend of movement with the older volcanos (over 25 Ma) being in the NE younging towards the SW with El Hierro being about 1 Ma. This is one of the most recent volcanos. The line is not quite straight because the Africa plate is rotating very slight anticlockwise (Diagram © Valentine Troll).

The geology of Fuerteventura shows the effects of different periods. The blue areas are Miocene eruptions whilst the brown colours show Pliocene and Quaternary period eruptions. The blue areas show 3 main eruptions. Due to the amount of erosion, it is possible to find evidence of the sub volcanic structure.





This is not so on Lanzarote which is much younger and as a result much less erosion has taken place.

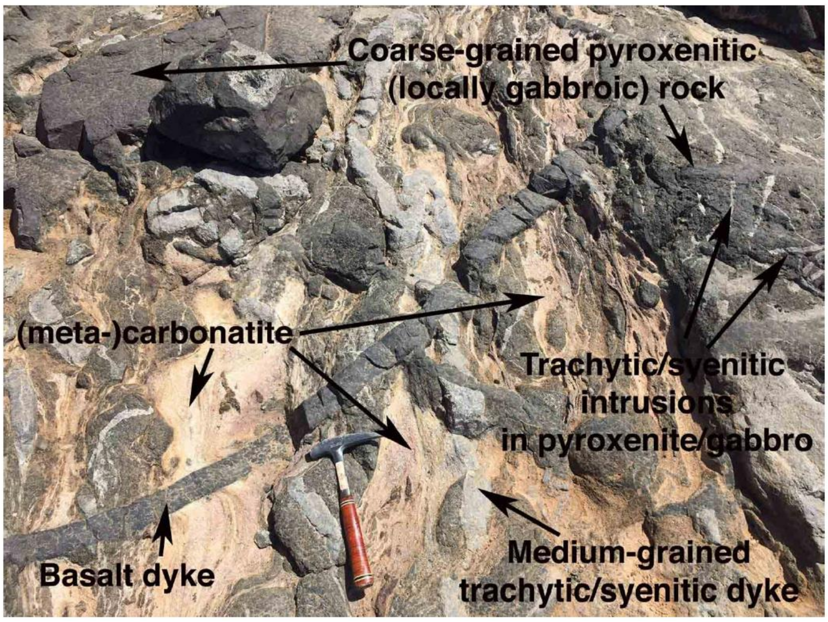
Lanzarote shows 2 main periods of eruption, The older eruptions (blue) and the younger areas (reds & greens) from 1730 – 36 and 1824.

These pictures show a sub volcanic gabbro pluton that is probably a laccolith rather than the main magma chamber (Batholith)

Alkali Carbonatite magmatism is primarily an intra plate igneous phenomenon that is only very rarely found within ocean plates. However, they are found on Fuerteventura and the Cape Verde Islands as sub-volcanic intrusives.

- Carbonatite contain more than 50% carbonate minerals, being mainly composed of Na_2O, CaO and CO_2 in a wide variety of minerals. Usually associated with silicate minerals such as pyroxene and silica-undersaturated minerals such as nephaline and feldspathoids.
- Arise from very small amounts of partial melting of the mantle.
- The melt is thought to travel upwards as an immiscible liquid containing a carbonate melt and a silicate melt (i.e. like oil & water).
- These melts separate at shallow depth; in this case to form dykes of carbonate and trachytic/syenitic material which solidified only a few cm apart.

In the image below, the carbonatite is a pale tan colour, whilst the trachytic /syenitic material is pale grey.



Phases of terrestrial volcano development upon seamounts in Lanzarote and Fuerteventura are:

- Miocene-Pliocene shield volcanoes. Youngest lavas 3.8-5.7 Ma.
- Erosion & catastrophic failure.
- Rejuvenation phase (Pliocene-Pleistocene).
- Sea Level Change &/or sedimentation.
- Pleistocene fissure volcanism.
- Modern erosion.
- The future – erosion back beneath the waves as there is insufficient magma to maintain them. There are a number of ancient islands to the NE of the canaries which have ben eroded back to seamounts.

Development of a shield volcano:

- Formed from very effusive fluid (unviscous) basaltic magma
- Low angle 2/3° - 10°
- Multiple eruptions with possible paleosols (fossil soil) between them
- Paleosols suggest long time intervals
- Cinder cones on flanks
- Can be 50km diameter

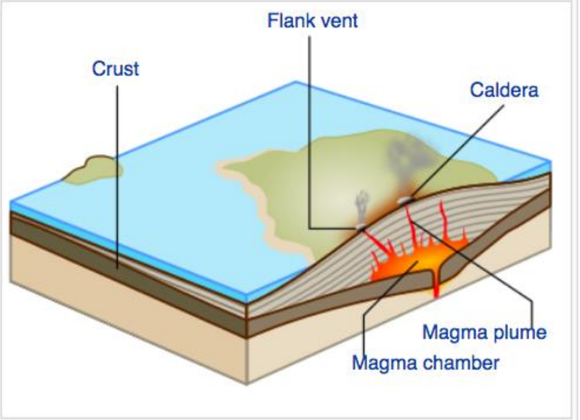
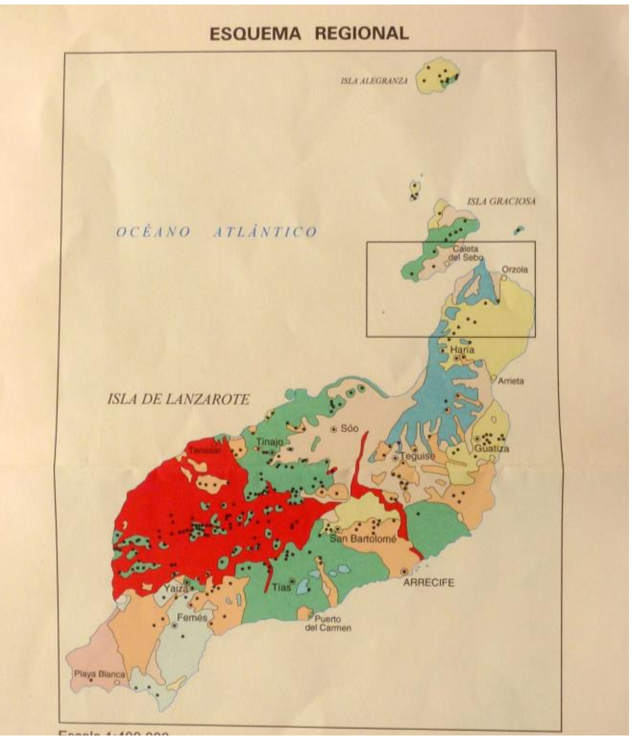


Diagram of the common structural features of a shield volcano.



Lanzarote shield volcanoes (blue). Partly covered by later material and also missing parts probably due to erosional collapse.

These volcanoes are underlain by a complex of intrusive dykes on top of which are layers of flowing lava creating the striped effect shown here. Sometimes between these layers are the bright red paleosols which indicate quite long periods of time between eruptions.

These volcanos are built in relatively short timescales; e.g. El Hierro built in about 1 million years has already collapsed.

The lava typically contains crystal inclusions that are mantle material brought up by the magma, e.g. pyroxenes and olivines

When these large shield volcanos collapse they do so in a pattern that leaves 3 upstanding arms with the collapse areas in between. These areas won't necessarily collapse all at once but rather in several stages, but when they suffer a major collapse they may create huge tsunamis in the Atlantic that could reach North America. As a result, some research into these issues has been financed by American insurance companies, as there is no tsunami warning system in the Atlantic. There is evidence of such tsunamis having occurred in the past.

There is also evidence on Lanzarote of much higher water levels in Pliocene times, approximately 50m higher than today. Limestone deposits plus fossils prove the point.

On Lanzarote, following the volcano building period and the subsequent collapse phase in the Pliocene there is a long period of inactivity. However, this map shows the later volcano building phase beginning in the 18th century (red and green colours). Most of the exposed deposits, apart from the original shield volcanoes (blue), were deposited in this later period.

These are fissure eruptions indicated by the number of chains of cinder (scoria) cones on the island. They are built up of loose pyroclastic fragments, such as volcanic clinkers, cinders, volcanic ash, or scoria. Formed by explosive eruptions or lava fountains from a single, typically cylindrical, vent.

Typical landscape consists of lava flows of ‘aa’ (blocky) lava plus lots of lava bombs, some of which can be the size of a small house! Also found are accretionary lava balls (Below right) which result from lava rolling down the side of a steep volcano (like a snowball).

Other types of deposit are lapilli (small, fine stones) and surge deposits of air-cooled ash, dumped from one of more eruptions. These deposits will have a large variety of volcanic fragments in their makeup.

The other type of lava deposit seen on Lanzarote is pahoehoe (ropey). This forms as lava slowly oozes forward, solidifying as it goes with a characteristic ropey appearance – hence the name.

Finally, there are also non-volcanic deposits such as wind blown sand and Caliche. Caliche is a pale carbonate-rich material or soil produced by the dissolution and re-precipitation of the carbonate, which has been deposited during a period of volcanic inactivity (or a pause). This carbonate originates from the sea either during a high stand period or is carried ashore by the wind. It may form a fine carbonate rich horizon or cement loose lava fragments together to form a coaster material. Both types were seen at this site.